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Eduardo Schwartz
Anderson Graduate School of Management
University of California, Los Angeles

and

Walter N. Torous
Anderson Graduate School of Management
University of California, Los Angeles

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Eduardo S. Schwartz and Walter N. Torous

Anderson School of Management
UCLA
Los Angeles, CA 90095

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Abstract

The consumption asset pricing framework implies that asset prices may be used to investigate the properties of consumption. An important property of consumption is its elasticity of intertemporal substitution which measures the willingness of individuals to move consumption between time periods in response to changes in interest rates and has important implications for the effectiveness of monetary policy and the behavior of the business cycle. However, consumption asset pricing models typically assume a power utility function in which the elasticity of intertemporal substitution cannot be disentangled from the coefficient of relative risk aversion. While the Epstein-Zin utility function breaks this link, extant empirical tests of this specification have not been able to disentangle these parameters. We argue that this failure arises because data previously used does not properly capture the time dimension needed to accurately estimate the elasticity of intertemporal substitution. We use term structure data, in particular "forward" portfolios which more accurately measure movements across points on the term structure. We find that the Epstein-Zin specification is consistent with our term structure data and we are able to clearly disentangle the elasticity of intertemporal substitution from the coefficient of relative risk aversion.

1 Introduction

One of the more important issues in macroeconomics is the response of savings and consumption to changes in real rates of interest. If, for example, individuals can be induced to alter their consumption plans in response to a change in interest rates, all else equal, the consequences of this action will have implications across a wide variety of macroeconomic dimensions including the effectiveness of monetary policy and the behavior of the business cycle. This response is estimated by the elasticity of intertemporal substitution in consumption.

The consumption asset pricing model, originally put forward by Breeden (1979), links the behavior of asset prices to consumption dynamics. Because of this link, asset returns can be used to investigate the properties of individuals' consumption decisions and indeed the recent literature has used this framework to refine our understanding of the pricing of risky assets (Cochrane and Hansen (1992)).

Empirical tests of the consumption asset pricing model typically assume a representative investor who maximizes the expectation of a time separable power utility function:

$$U_t = E_t\{\sum_{j=0}^{\infty} \delta^j \frac{C_{t+j}^{1-\gamma} - 1}{1-\gamma}\} \tag{1}$$

where δ is the rate of time preference, C_t is the investor's consumption in period t and γ is the coefficient of relative risk aversion. Unfortunately, most of these tests give unreasonably high estimates of the coefficient of relative risk aversion that are not consistent with the observed portfolio holdings of actual investors (see, for example, Blume and Friend (1975)). This same conclusion can also be arrived at by using the volatility bounds analysis of Hansen and Jagannathan (1991).

An alternative specification for preferences has been suggested by Epstein and Zin (1991) and Weil (1989). This specification retains many of the attractive features of the power utility function but is no longer time separable. In particular, the utility function can be defined recursively as follows:

$$U_t = \{(1-\delta)C_t^{\frac{1-\gamma}{\theta}} + \delta(E_t(U_{t+1}^{1-\gamma})^{\frac{1}{\theta}})\}^{\frac{\theta}{1-\gamma}} \tag{2}$$

for $\theta \equiv (1-\gamma)/(1-1/\psi)$ where ψ is the elasticity of intertemporal substitution (the derivative of planned log consumption growth with respect to the log interest rate), γ and δ, as before, are the coefficient of relative risk aversion and the rate of time preference, respectively. When $\theta = 1$, or alternatively when $\gamma = 1/\psi$, this specification reduces to a time-separable power utility model.

With a power utility function the elasticity of intertemporal substitution is the reciprocal of the coefficient of relative risk aversion. However, Hall (1988) argues that this specification is inappropriate because the elasticity of intertemporal substitution deals with the willingness of an investor to move consumption *between time periods* and is well defined even in the absence of uncertainty. In contrast, the coefficient of relative risk aversion concerns the willingness of an investor to move consumption *between states of the world* and is well defined even in a one period model. The Epstein-Zin specification, however, breaks this link between the coefficient of relative of risk aversion and the elasticity of intertemporal substitution implicit in the power utility function.

In spite of the theoretical appeal of the Epstein-Zin specification, empirical tests have not been successful in disentangling the elasticity of intertemporal substitution from the coefficient of relative risk aversion.[1] In this article, we argue that this failure arises

[1]See, for example, Epstein and Zin (1991) and Smith (1998).

because the data used in these tests, which includes returns to stocks and holding period returns on bonds with short maturities (typically less than one year) [2], do not capture the time dimension needed to accurately measure the elasticity of intertemporal substitution. Since the elasticity of intertemporal substitution deals with the willingness of investors to allocate their consumption over time, we propose to use term structure data that allows us to capture this temporal effect.

Recall that consumption asset pricing models are typically estimated and tested based on the first order or Euler conditions of the corresponding representative investor's maximization problem. Since these first-order conditions hold for any subset of assets, the researcher has a choice as to which assets to include in the estimation. Past studies have concentrated on excess stock returns[3] because their primary objective was, in many instances, to resolve the equity premium puzzle. Our objective, however, is to simply improve our understanding of the relation between relative risk aversion and the elasticity of intertemporal substitution and we use term structure data to achieve this goal.

The limited empirical research using term structure data in consumption asset pricing models, however, has used holding period returns on discount bonds. Holding period returns on discount bonds of differing maturities are not able to accurately isolate movements across different points of the term structure because the holding period returns on these bonds depend on the movements of all forward rates up to the maturity of the bond. This overlap introduces a potentially large noise component into the estimation. Not only do we extend the maturity of the bonds used to five years, but more importantly, we minimize this noise by constructing "forward" portfolios that allow us to more accu-

[2]See, for example, Dunn and Singleton (1986). An exception is Roma and Torous (1997).
[3]See, for example, Hansen and Singleton (1983) and Ferson and Constantinides (1991).

rately capture movements across different points of the term structure. These portfolios include a long position in a longer term discount bond and a short position in a shorter term discount bond allowing us to capture the movements in the term structure between these maturities.

The main conclusion of this article is that the Epstein-Zin specification is consistent with the term structure data we use. Moreover, we are able to clearly disentangle the coefficient of relative aversion from the elasticity of intertemporal substitution. In addition, the utility function parameters we estimate are within the range that the extant literature considers to be reasonable. Our study suggests that the disentanglement of risk aversion from intertemporal substitution may be an important ingredient in consumption-based equilibrium asset pricing models, in particular, equilibrium models of the term structure.

This article is organized as follows. In Section 2 we describe our data and how we construct the "forward" portfolios. Section 3 applies the Hansen-Jagannathan volatility bounds analysis to the power utility model as well as to the Epstein-Zin specification. The empirical tests are presented in Section 4 while Section 5 concludes.

2 Data and Portfolio Construction

2.1 Term Structure Data

The basic data used in this study are discount Treasury bond prices (the average of the bid and ask) obtained from the CRSP Fama-Bliss files. They include Treasury Bills with maturities of three, six, nine and twelve months and constructed discount Treasury Bonds with maturities of two, three, four and five years over the sample period 1964:3 to 1997:4. Since we rely on quarterly consumption data in our empirical analyses, we also

use quarterly bond price data.

Traditionally consumption based asset pricing models have been tested using holding period returns computed by investing a dollar in a discount bond with a particular maturity and then closing this position after a given period of time, in our case, one quarter. Unfortunately, a consequence of this is that the holding period returns on bonds of similar maturities will be highly correlated. This follows from the fact that bond price changes are driven by changes in forward rates and, to the extent that most of these forward rates are common to bonds of similar maturities, their price changes will also be similar. In fact, the only difference in these price changes is due to the forward rate which extends from the maturity of the shorter maturity bond to that of the longer maturity bond. These holding period returns, as a result, may not provide sufficient independent information to allow precise estimation.

It is reasonable then to investigate holding period returns of portfolios that are affected by movements in only one particular forward rate as opposed to all the forward rates up to the maturity of a bond. This is the approach taken in this article. An additional advantage of this approach is that holding period returns of our portfolios will have similar volatilities, whereas traditional holding period returns of discount bonds with very different maturities will have very different volatilities. Therefore, for this reason as well we may expect more precise estimation results using our alternative approach.

In particular, to take a position in a forward rate, for example, between years two and three, we invest one dollar in the three-year discount bond and take a short position of one dollar in the two-year discount bond and then hold this position for three months. Since this position has a zero net investment, we also invest in a three-month discount

bond (the risk free asset in this context) so that we can calculate a holding period return associated with the position. After one quarter, the two-year discount bond becomes a one and three-quarter year discount bond and similarly the three-year discount bond becomes a two and three-quarter year discount bond. We must approximate the prices of these bonds because for maturities longer than one year because prices in the Fama-Bliss files are only available on discount bonds with constant maturities of two, three, four or five years. We do so, for example, in the case of the one and three-quarter year bond, by linearly interpolating between the prevailing yields on the two-year and one-year discount bonds to give the yield on a one and three-quarter year discount bond which we then use to compute the price of that bond. For maturities of less than one year we do not need to interpolate as the required price data is available.

Since we have price data on discount bonds with eight separate maturities, we can construct eight of our "forward" portfolios on a quarterly basis. The first portfolio involves investing one dollar in the three-month discount bond. The second portfolio involves investing one dollar in the six-month discount bond, which is equivalent to investing one dollar in the six-month bond, taking a short position of one dollar in the three-month bond and investing one dollar in the three-month bond. The third portfolio consists of an investment of one dollar in the nine-month bond, a short position of one dollar in the six-month bond and an investment of one dollar in the three-month bond. All subsequent portfolios are similarly constructed.

Note that all the "forward" portfolios defined above have a position in the three-month discount bond. The purpose of this is to avoid having zero net investment portfolios for which rates of returns are not defined. To eliminate this common influence in all portfolios, our tests use excess returns, that is, returns on our "forward" portfolios in

excess of the three-month rate.

Since the consumption-based asset pricing models we are testing deal with real holding period returns, we convert the nominal holding period returns of our portfolios to real returns using the CPI deflator obtained from CITIBASE.

2.2 Stock Market Data

The Epstein and Zin specification requires a measure of the return on aggregate wealth. Following the literature, we proxy this return by the return on the CRSP value weighted (VW) portfolio. Similarly, we convert these nominal returns into real returns using the CPI deflator.

2.3 Consumption Data

In addition to real returns to assets, the consumption-based models require data on the real growth rate in consumption. Consumption data is available on a quarterly basis and is measured by the sum of the consumption of non-durables and services, denominated in real terms and obtained from CITIBASE.

2.4 Summary Statistics

Table 1 provides the descriptive statistics for the quarterly real holding period returns of the eight bond portfolios. As can be seen, the mean return is similar across the portfolios, as is their standard deviation. This is in contrast to the holding period returns on discount bonds where the volatility of long term bonds is dramatically greater than that of short

term bonds.[4] Also note that the portfolio return distributions are non-normal as evidenced by the relatively high values of the Jarque-Bera statistic.

Table 2 shows the correlation matrix for the quarterly real holding period returns to the eight bond portfolios, for the real quarterly return on the market portfolio, and the quarterly real consumption growth rate. The correlations between the bond portfolio returns are high reflecting the common influence of the three-month rate, but tend to be decreasing with increasing difference in maturities.

Tables 3 and 4 provide the same information as Tables 1 and 2, but now for excess returns to the bond portfolios. From Table 3 we see that excess returns appear to deviate more from normality for shorter maturities but are closer to normality for longer maturities. The most important differences, however, are in the correlation properties of the excess returns. We see in Table 4 that the correlations between the excess returns to the bond portfolios are substantially less correlated than the returns themselves are. In addition, the excess returns and consumption growth rates are more negatively correlated.

3 Hansen-Jagannathan Bounds

As a preliminary to our empirical analysis, we now turn our attention to the Hansen-Jagannathan bounds for the volatility of the representative investor's intertemporal marginal rate of substitution. Previously this analysis has been applied to stock returns (Cochrane and Hansen (1992)) and holding period returns to Treasury Bills (Luttmer (1996)). By finding the feasible region for means and standard deviations of the posited stochastic

[4]For example, for our data over the 1964:3 to 1997:4 sample period, the standard deviation of the quarterly real holding period return to the three month discount bond is 0.0077 while the volatility of the quarterly real holding period return to the sixty month discount bond is 0.0428.

discount factor, we can determine whether there are reasonable specifications of the corresponding utility function consistent with the holding period returns to our portfolios. We perform this analysis both for the power utility function as well as the Epstein and Zin specification. Note that since our analysis is illustrative, in neither case do we take into account the computationally more demanding requirement that the stochastic discount factor be a non-negative random variable (see Hansen and Jagannathan (1991)). These results should also be interpreted somewhat cautiously because we also ignore any sampling error associated with the Hansen-Jagannathan bound (Burnside (1994)).

3.1 Power Utility

Figures 1 to 4 show the results for a consumption based asset pricing model with power utility. In Figure 1 we use the eight portfolios defined in the previous section over the entire sample period and in Figure 2 we restrict our attention to the post-Fed experiment period of 1979:4 to 1997:4. Note that in both cases the coefficient of relative risk aversion required to satisfy the bounds is extremely large (γ=501 for the whole sample period and γ=441 for the later sample period). Consistent with previous studies, unreasonably large γ values are needed, suggesting a rejection of the power utility specification.

To assess whether these results are robust to the choice of portfolios, Figures 3 and 4 repeat the analysis in Figures 1 and 2, but using only a subset of the eight portfolios. We use the first, fifth and eight portfolios corresponding to the three-month discount bond, the forward portfolio between nine months and one year, and the forward portfolio between four and five years, respectively. As can be seen from these figures, the results are invariant to the portfolios used.

3.2 Epstein-Zin Utility

In Figures 5 to 8 we repeat the previous Hansen-Jagannathan analysis but now assuming an Epstein-Zin utility specification instead of the power utility. Recall that in this case the coefficient of relative risk aversion is distinct from the elasticity of intertemporal substitution. In each figure we select three values of ψ and we plot the mean and standard deviation of the resultant stochastic discount factor for a range of γ values.

In Figure 5 we use the eight portfolios over the entire sample period. As can be seen, for two of the three chosen ψ values, $\psi = 0.14$ and $\psi = 0.16$, the Hansen-Jagannathan bounds are satisfied by γ values which are of an order of magnitude smaller than in the power utility case ($\gamma = 83$ and $\gamma = 64$, respectively). For the third chosen ψ value, $\psi = 0.18$, there does not exist a value of γ that satisfies the bounds. In Figure 6 we consider the post Fed experiment period of 1979:4 to 1997:4, and the results are similar. Figures 7 and 8 repeat the analysis in Figures 5 and 6, but using only the subset of the portfolios. As before, the results appear to be invariant to the portfolios used.

Since the coefficients of relative risk aversion obtained are an order of magnitude smaller, these results suggest that the Epstein-Zin utility specification is better able to capture the characteristics of our data and that the distinction between the elasticity of intertemporal substitution and the coefficient of relative risk aversion may be more evident in term structure data. Though suggestive, these results do not represent a formal empirical test of the adequacy of the Epstein-Zin model. In the next section we perform these tests.

4 Empirical Tests

As shown by Epstein and Zin (1991), their utility specification (2) together with the intertemporal budget constraint implies the following first order condition:

$$E_t\{(\delta(\frac{C_{t+1}}{C_t})^{-\frac{1}{\psi}})^{\theta}\ (\frac{1}{1+R_{m,t+1}})^{1-\theta}(1+R_{p,t+1})\} = 1 \tag{3}$$

for $\theta \equiv (1-\gamma)/(1-1/\psi)$ where C_t is the log real consumption of non durables and services at quarter t, $R_{m,t}$ is the real return to the CRSP value weighted index, and $R_{p,t}$ is the real holding period return to our "forward" portfolios.

These first order conditions can also be expressed in excess return form as:

$$E_t\{(\delta(\frac{C_{t+1}}{C_t})^{-\frac{1}{\psi}})^{\theta}\ (\frac{1}{1+R_{m,t+1}})^{1-\theta}(R_{p,t+1}-R_{f,t+1})\} = 0 \tag{4}$$

where $R_{f,t+1}$ denotes the three-month Treasury Bill rate.

We use the generalized method of moments (GMM) to estimate the parameters of the utility function.

Our main results are given in Tables 5 and 6. Since the first order conditions hold for any portfolio, we include excess returns to four of our portfolios: the nine-month, two-year, four-year and five-year portfolios. Since these portfolios would not provide any information about the three month rate and, as such, the prevailing level of rates, we also include the return on our first portfolio, the three-month Treasury Bill. We selected these excess return portfolios to span the whole range of available maturities to better capture the time dimension inherent in investors' consumption and investment decisions. Attempts to include more portfolios were not successful since they invariably resulted in

almost linearly dependent moment conditions.[5] The instruments used were the included variables lagged one, two and three quarters.

Table 5 shows the results for the entire sample period. The point estimate for the coefficient of relative risk aversion is $\hat{\gamma} = 5.65$ and is estimated precisely with a standard error of 0.22. This value is close to the coefficient of relative risk aversion obtained by Blume and Friend (1975) and others from data on actual portfolio holdings of individual investors. The point estimate for the elasticity of intertemporal substitution is $\hat{\psi} = 0.226$ with a standard error of 0.008. This point estimate is roughly consistent with the earlier results of Epstein and Zin (1991), though our estimate is far more precise. This is to be expected since we have restricted our attention to portfolios specially designed to capture the time dimension of the representative investor's consumption-investment decision. Like Hall (1988) we conclude that the elasticity of intertemporal substitution is small and positive, though statistically distinguishable from zero. We also present the results of a Wald test to investigate whether the elasticity of intertemporal substitution is the reciprocal of the coefficient of relative risk aversion as implied by the time separable power utility function. As can be seen we can easily reject this null hypothesis, suggesting that the Epstein-Zin specification provides a more accurate description of our term structure data. Finally, the point estimate for the rate of time preference parameter is $\hat{\delta} = 0.9892$ and a Wald test can reject the null hypothesis that this parameter equals one.

To investigate the robustness of our results[6] we repeat the above analysis over the 1979:4 to

[5]All estimation was carried out on EViews, Version 3.1. In particular, we used the GMM - Time series routine invoking the prewhitening option, a Bartlett kernel and Newey and West's fixed bandwith selection criterion. The GMM algorithm was allowed to iterate to convergence.

[6]Our results are also robust with respect to the portfolios used in the GMM estimation so long as the portfolios span the whole range of available maturities. For example, if we include excess returns to the six-month, two-year, four-year and five-year portfolios as well as the three-month returns we obtain the following parameter estimates (with asymptotic standard errors in parentheses) over the 1964:3 to 1997:4

1997:4 subperiod and the results are presented in Table 6. Overall these results are similar but the evidence against the equality of the elasticity of intertemporal substitution and the reciprocal of the coefficient of relative risk aversion is slightly weaker, but significant at the 10% level, perhaps reflecting the fewer number of time series observations.

5 Conclusions

This article poses the question as to whether it is possible to disentangle the coefficient of relative risk aversion from the elasticity of intertemporal substitution in consumption. It is well known that for the case of a time separable power utility function the former is by construction the reciprocal of the latter. Therefore this question can only be resolved by a utility function which explicitly distinguishes between the two, such as the Epstein-Zin specification. Even though this specification allows for this flexibility, empirical studies have not heretofore been able to clearly disentangle these parameters.

In this article, we have argued the reason for this failure is that the data used in previous studies is simply not appropriate to answer this question. We use term structure data not only with maturities up to five years but also looking at movements across different points in the term structure. Using portfolios that mimic these forward rate movements we are able to estimate the parameters of the Epstein-Zin specification and statistically reject the null hypothesis of equality between the coefficient of relative risk aversion and the reciprocal of the elasticity of intertemporal substitution. In particular, US term structure data over the 1964 to 1997 sample period is consistent with a small but positive elasticity

sample period: $\hat{\delta} = 0.9947(0.0001)$, $\hat{\gamma} = 13.7774(0.3293)$, and $\hat{\psi} = 0.1505(0.0040)$. A Wald test can also easily reject the null hypothesis that $\theta = 1$.

elasticity of intertemporal substitution suggesting that consumers can indeed be induced to postpone consumption by modest increases in interest rates.

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Table 1

Summary Statistics for Quarterly Holding Period Returns to Forward Portfolios

This table provides summary statistics for the quarterly real holding period returns, $fret_\tau$, to forward portfolios with maturity τ. The sample period is 1964:3 to 1997:4. The Jarque-Bera statistic tests whether a return series is normally distributed and its asymptotic p-value is in parentheses.

	$fret_{03}$	$fret_{06}$	$fret_{09}$	$fret_{12}$	$fret_{24}$	$fret_{36}$	$fret_{48}$	$fret_{60}$
Mean	0.0034	0.0055	0.0041	0.0045	0.0032	0.0039	0.0039	0.0033
Median	0.0031	0.0045	0.0035	0.0041	0.0019	0.0025	0.0034	0.0031
Maximum	0.0284	0.0419	0.0381	0.0419	0.0569	0.0585	0.0598	0.0598
Minimum	-0.0196	-0.0202	-0.0224	-0.0272	-0.0379	-0.0319	-0.0252	-0.0302
Standard Deviation	0.0077	0.0092	0.0094	0.0099	0.0153	0.0136	0.0128	0.0125
Skewness	0.3249	0.7642	0.5325	0.2118	0.7056	0.4947	0.7916	0.7736
Kurtosis	4.3250	5.7518	4.9230	4.6037	5.2201	4.5705	5.6457	5.8283
Jarque-Bera Statistic	12.1595	55.3220	26.9797	15.3610	38.6364	19.2355	53.0770	58.0269
	(0.0022)	<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)

Table 2

Correlation Properties of Quarterly Holding Period Returns to Forward Portfolios

This table gives the correlation coefficients between quarterly holding period returns to forward portfolios, $fret_\tau$, as well as the quarterly growth rate in the real consumption of non-durables and services, *cgrowth*, and the quarterly real return to the CRSP Value-Weighted portfolio, ret_m. The sample period is 1964:3 to 1997:4.

	$fret_{03}$	$fret_{06}$	$fret_{09}$	$fret_{12}$	$fret_{24}$	$fret_{36}$	$fret_{48}$	$fret_{60}$	*cgrowth*	ret_m
$fret_{03}$	1									
$fret_{06}$	0.9362	1								
$fret_{09}$	0.9421	0.9701	1							
$fret_{12}$	0.9274	0.9325	0.9536	1						
$fret_{24}$	0.7790	0.8662	0.9112	0.8629	1					
$fret_{36}$	0.8017	0.8339	0.8884	0.8854	0.9378	1				
$fret_{48}$	0.7915	0.8287	0.8545	0.8396	0.9003	0.9080	1			
$fret_{60}$	0.7801	0.7933	0.8394	0.8526	0.8469	0.8915	0.7732	1		
cgrowth	0.0520	-0.0509	-0.0319	0.0224	-0.0859	-0.0309	-0.0509	0.0071	1	
ret_m	0.2797	0.3021	0.3337	0.3585	0.3721	0.3900	0.3137	0.3714	0.1316	1

Table 3

Summary Statistics for Quarterly Excess Holding Period Returns to Forward Portfolios

This table provides summary statistics for the quarterly real holding period returns to forward portfolios with maturity τ in *excess* of the three-month risk free rate, $xfret_\tau$. The sample period is 1964:3 to 1997:4. The Jarque-Bera statistic tests whether a return series is normally distributed and its asymptotic p-value is in parentheses.

	$xfret_{06}$	$xfret_{09}$	$xfret_{12}$	$xfret_{24}$	$xfret_{36}$	$xfret_{48}$	$xfret_{60}$
Mean	0.0021	0.0007	0.0011	-0.0002	0.0005	0.0005	-0.0001
Median	0.0017	0.0001	0.0009	-0.0017	0.0003	-0.0007	-0.0005
Maximum	0.0198	0.0211	0.0142	0.0460	0.0301	0.0322	0.0314
Minimum	-0.0089	-0.0111	-0.0159	-0.0265	-0.0280	-0.0189	-0.0217
Standard Deviation	0.0034	0.0034	0.0040	0.0105	0.0087	0.0082	0.0081
Skewness	1.3154	1.4585	-0.1781	0.8000	-0.0014	0.4173	0.3511
Kurtosis	9.5628	13.1620	6.0154	5.4944	3.8441	4.1002	4.6841
Jarque-Bera Statistic	279.1138	624.0720	51.4744	49.0325	3.9779	10.6487	18.5889
	<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(0.1368)	(0.0048)	(0.0001)

Table 4

Correlation Properties of Quarterly Excess Holding Period Returns to Forward Portfolios

This table gives the correlation coefficients between quarterly excess holding period returns to forward portfolios, $xfret_{\tau}$, as well as the quarterly growth rate in the real consumption of non-durables and services, *cgrowth*, and the quarterly real return to the CRSP Value-Weighted portfolio, ret_m. The sample period is 1964:3 to 1997:4.

	$xfret_{06}$	$xfret_{09}$	$xfret_{12}$	$xfret_{24}$	$xfret_{36}$	$xfret_{48}$	$xfret_{60}$	*cgrowth*	ret_m
$xfret_{06}$	1								
$xfret_{09}$	0.7691	1							
$xfret_{12}$	0.5374	0.6829	1						
$xfret_{24}$	0.6564	0.8630	0.6581	1					
$xfret_{36}$	0.4541	0.7056	0.6839	0.8586	1				
$xfret_{48}$	0.4551	0.5773	0.5188	0.7661	0.7733	1			
$xfret_{60}$	0.3351	0.5388	0.5893	0.6417	0.7331	0.4509	1		
cgrowth	-0.2586	-0.2089	-0.0448	-0.1639	-0.0942	-0.1286	-0.0385	1	
ret_m	0.1856	0.2919	0.3498	0.3372	0.3601	0.2265	0.3075	0.1316	1

Table 5

Generalized Method of Moments Estimates of the Epstein-Zin Utility Specification: Full Sample

This table provides Generalized Method of Moments estimates of the parameters of the Epstein and Zin (1991) utility specification

$$U_t = \{(1-\delta)C_t^{(1-\frac{1}{\psi})} + \delta(E_t(U_{t+1}^{1-\gamma})^{\frac{1}{\theta}})\}^{(1-\frac{1}{\psi})}$$

when applied to quarterly excess holding period returns to forward portfolios of maturities nine months ($xfret_9$), twenty-four months ($xfret_{24}$), forty-eight months ($xfret_{48}$), and sixty months ($xfret_{60}$), as well as the quarterly holding period returns to a portfolio with maturity three months ($fret_3$). Here ψ is the elasticity of intertemporal substitution, γ and δ are the coefficient of relative risk aversion and the rate of time preference, respectively, and $\theta \equiv (1-\gamma)/(1-1/\psi)$. The sample period is 1964:3 to 1997:4. The instruments used include a constant and values of the included return series as well as the growth rate in real consumption and the real return to the $CRSP$ value-weighted portfolio all lagged one, two and three quarters. Asymptotic standard errors of the parameter estimates are provided in parentheses. The test of the model's overidentifying restrictions is denoted by χ^2 with its p-value in parenthesis. We also provide the p-values associated with Wald tests of the restriction $\delta = 1$ and $\theta = 1$, the latter restriction being consistent with the Epstein-Zin utility specification reducing to a power utility specification.

δ	γ	ψ	χ^2	Wald test: $\delta = 1$	Wald test: $\theta = 1$
0.9892	5.6517	0.2258	28.0509	$p < 0.0001$	$p < 0.0001$
(0.0001)	(0.2203)	(0.0083)	(p >0.99)		

Table 6

Generalized Method of Moments Estimates of the Epstein-Zin Utility Specification: Post-1979 Sample

This table provides Generalized Method of Moments estimates of the parameters of the Epstein and Zin (1991) utility specification

$$U_t = \{(1-\delta)C_t^{(1-\frac{1}{\psi})} + \delta(E_t(U_{t+1}^{1-\gamma})^{\frac{1}{\theta}})\}^{(1-\frac{1}{\psi})}$$

when applied to quarterly excess holding period returns to forward portfolios of maturities nine months ($xfret_9$), twenty-four months ($xfret_{24}$), forty-eight months ($xfret_{48}$), and sixty months ($xfret_{60}$), as well as the quarterly holding period returns to a portfolio with maturity three months ($fret_3$). Here ψ is the elasticity of intertemporal substitution, γ and δ are the coefficient of relative risk aversion and the rate of time preference, respectively, and $\theta \equiv (1-\gamma)/(1-1/\psi)$. The sample period is 1979:4 to 1997:4. The instruments used include a constant and values of the included return series as well as the growth rate in real consumption and the real return to the $CRSP$ value-weighted portfolio all lagged one, two and three quarters. Asymptotic standard errors of the parameter estimates are provided in parentheses. The test of the model's overidentifying restrictions is denoted by χ^2 with its p-value in parenthesis. We also provide the p-values associated with Wald tests of the restriction $\delta = 1$ and $\theta = 1$, the latter restriction being consistent with the Epstein-Zin utility specification reducing to a power utility specification.

δ	γ	ψ	χ^2	Wald test: $\delta = 1$	Wald test: $\theta = 1$
0.9882	8.8281	0.1096	24.2239	$p < 0.0001$	$p = 0.0837$
(0.0003)	(0.4008)	(0.0043)	(p >0.99)		

FIGURE 1
Hansen-Jagannathan Bounds for Power Utility
Eight Maturities for Sample Period 1964:1 to 1997:4

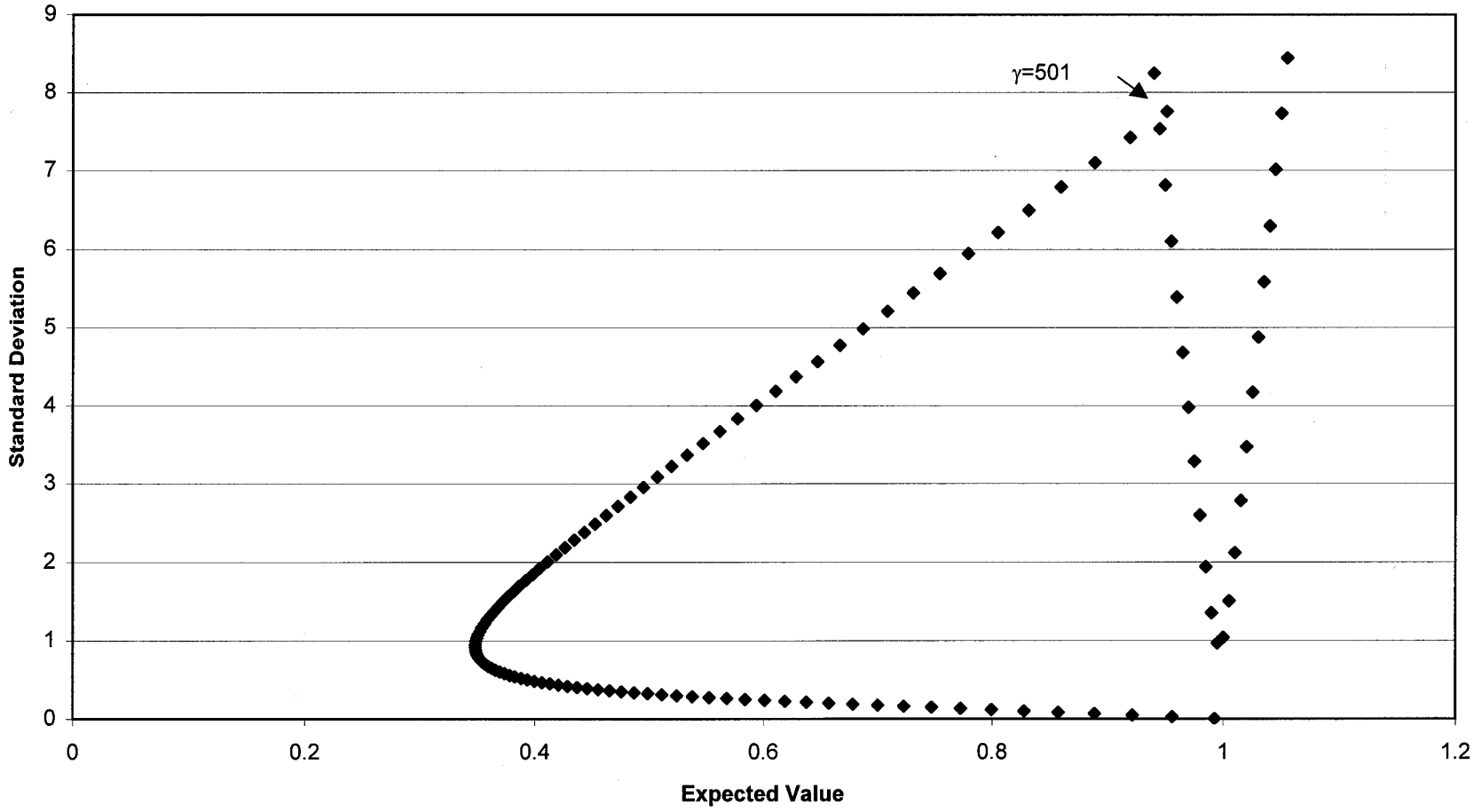

FIGURE 2
Hansen-Jagannathan Bounds for Power Utility
Eight Maturities for Sample Period 1979:4 to 1997:4

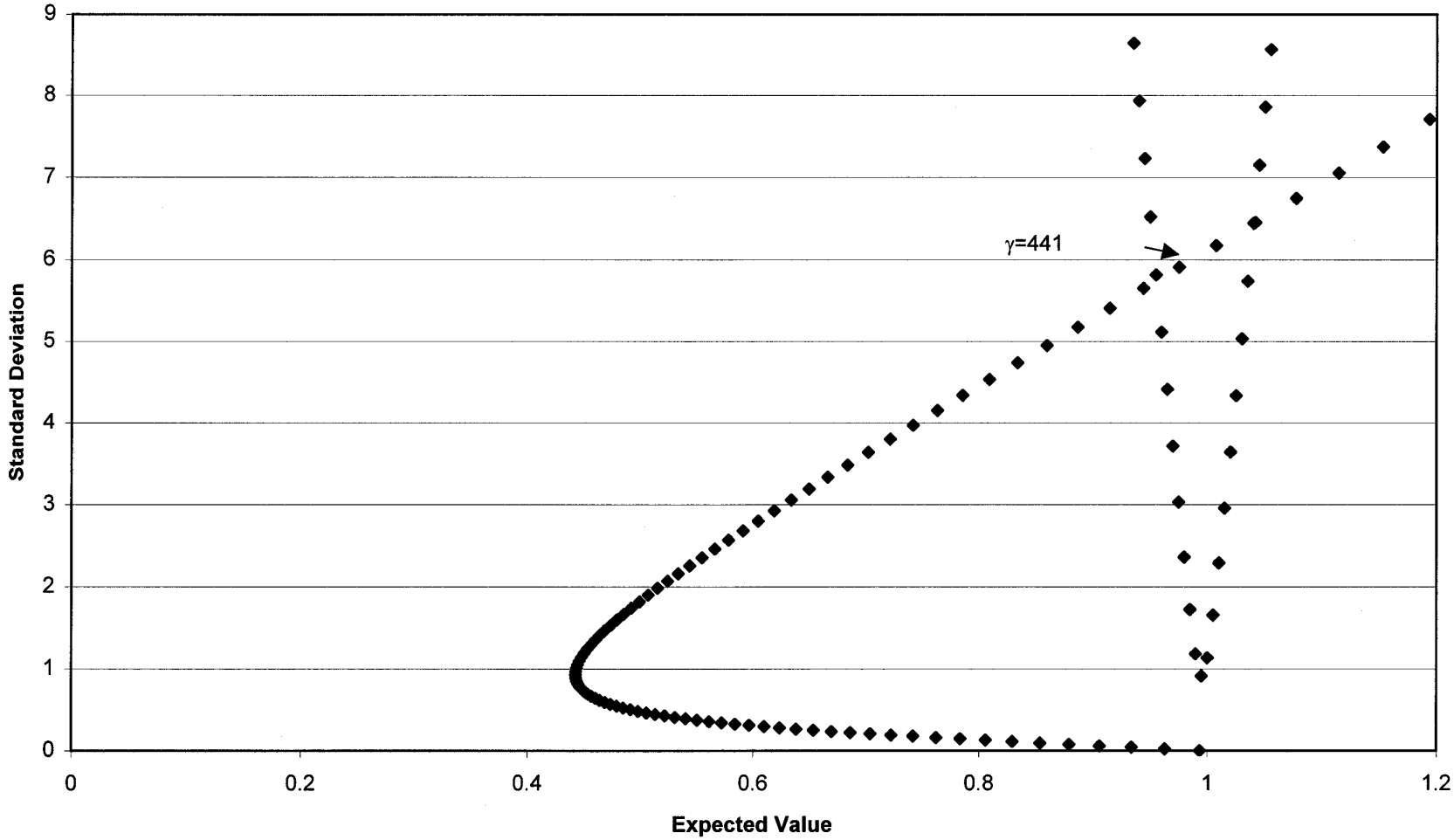

FIGURE 3
Hansen-Jagannathan Bounds for Power Utility
Three Maturities for Sample Period 1964:1 to 1997:4

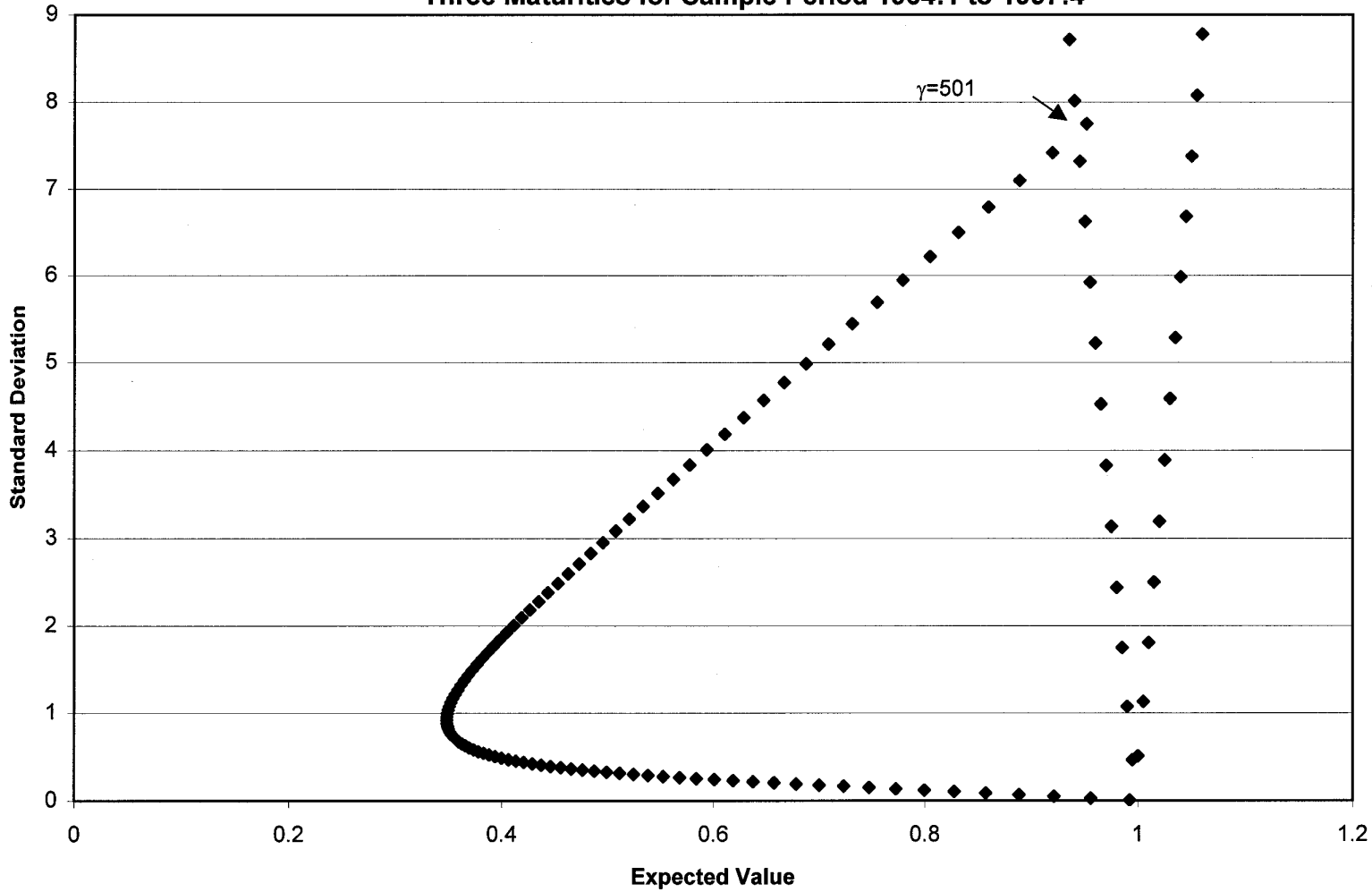

FIGURE 4
Hansen-Jagannathan Bounds for Power Utility
Three Maturities for Sample Period 1979:4 to 1997:4

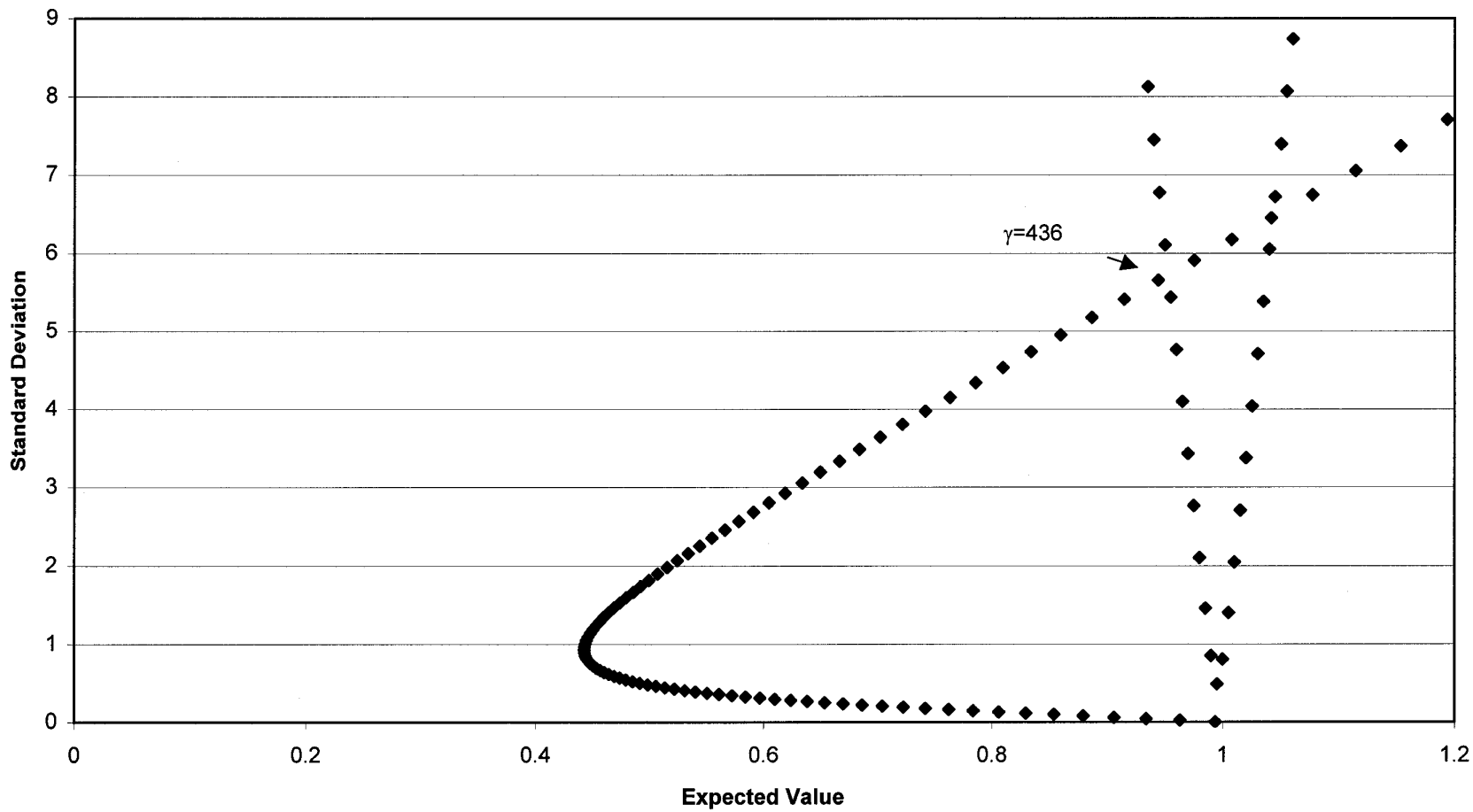

FIGURE 5
Hansen-Jagannathan Bounds for Epstein-Zin Utility
Eight Maturities for Sample Period 1964:1 to 1997:4

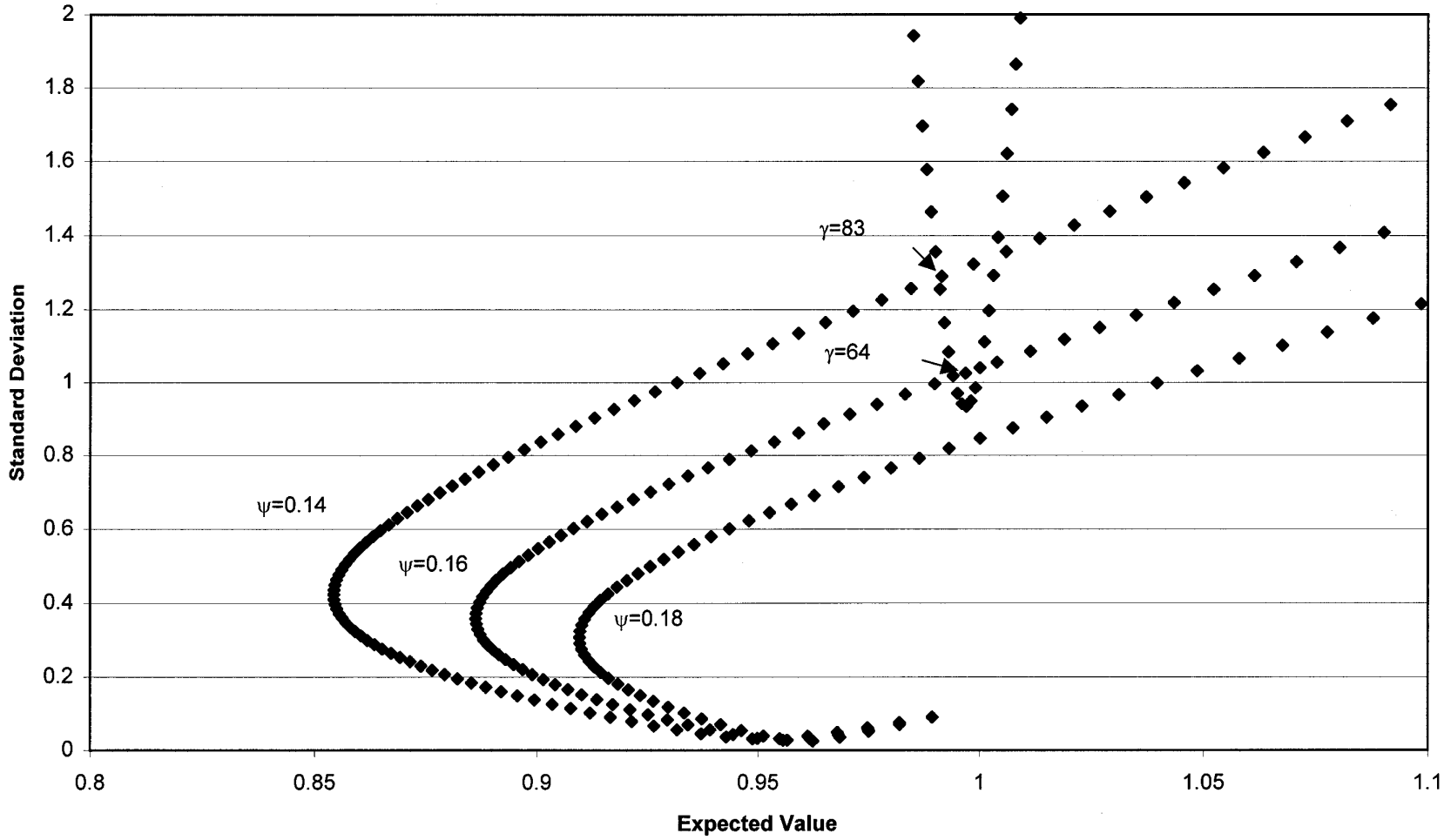

FIGURE 6
Hansen-Jagannathan Bounds for Epstein-Zin Utility
Eight Maturities for Sample Period 1979:4 to 1997:4

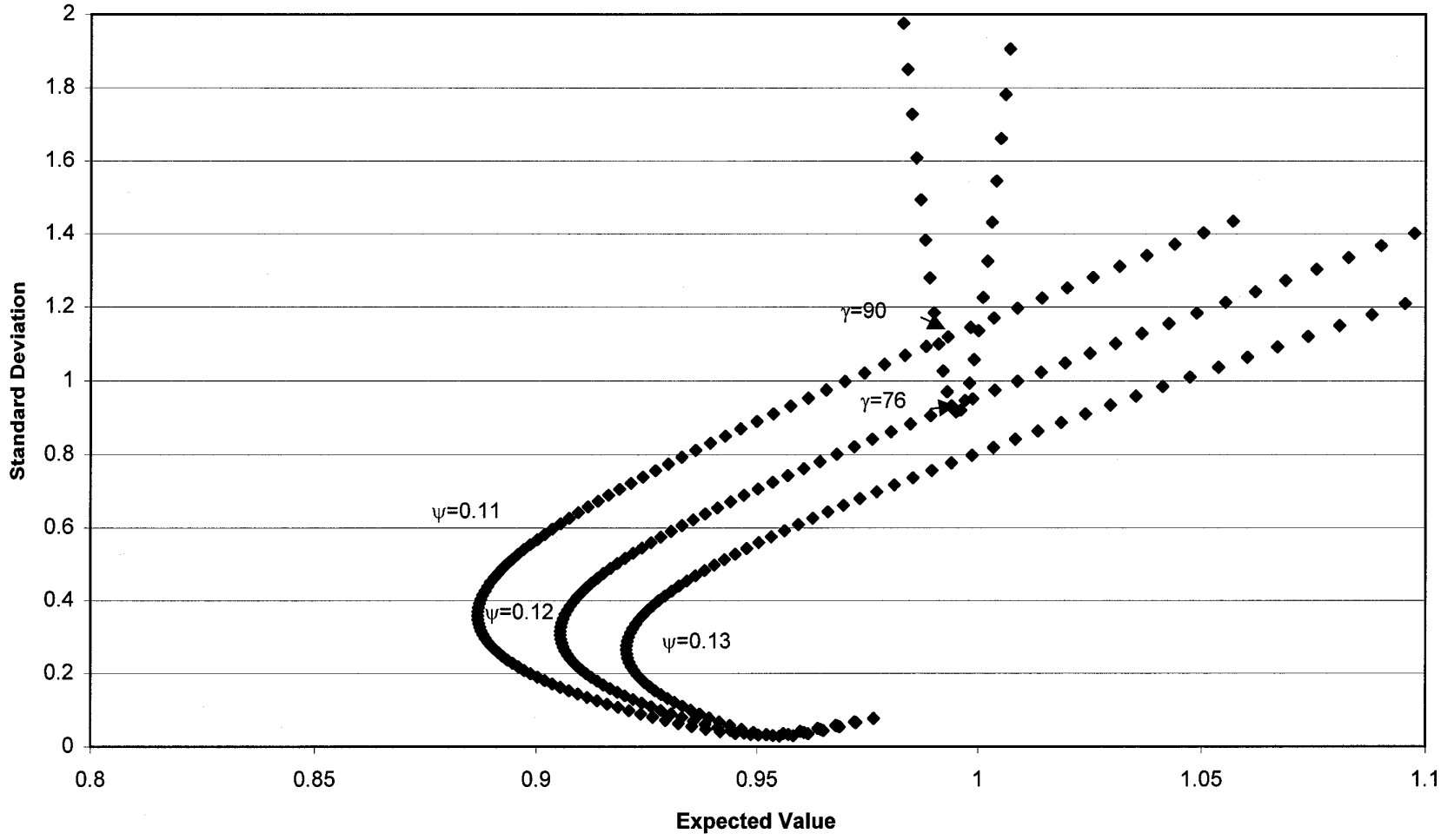

FIGURE 7
Hansen-Jagannathan Bounds for Epstein-Zin Utility
Three Maturities for Sample Period 1964:1 to 1997:4

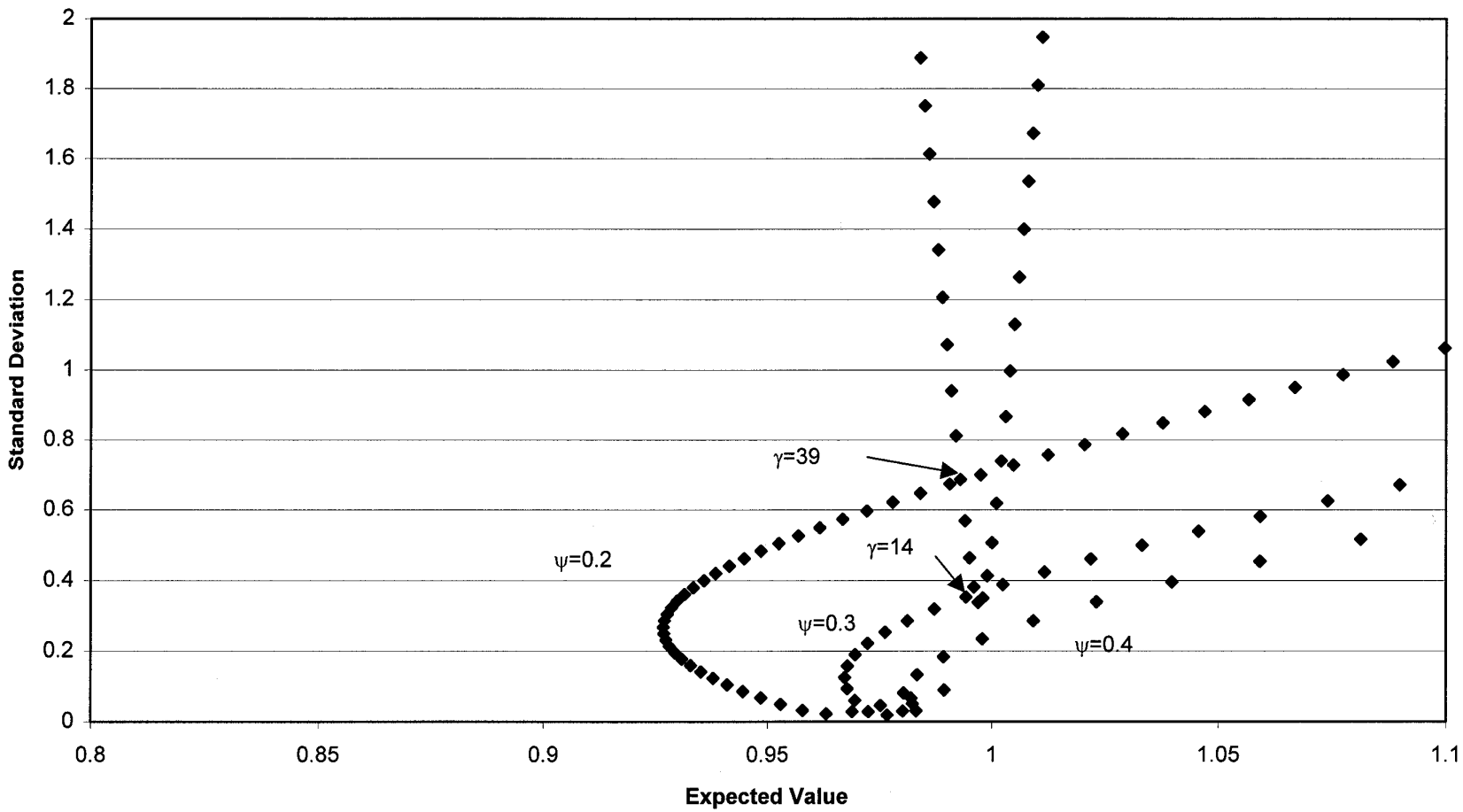

FIGURE 8
Hansen-Jagannathan Bounds for Epstein-Zin Utility
Three Maturities for Sample Period 1979:4 to 1997:4